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NATURAL SCIENCE.

WILBUR S. JACKMAN.

SOME APPLICATIONS OF NUMBER WORK TO NATURE STUDY.

EVERY observation is made and repeated for the purpose of defining a picture or image. Number work is a means of defining a picture or image through a determination of quantity. In the application of number, therefore, the same principles must be observed that are employed in defining the image by other means.

1. There must be a clear conception of the image to be developed. Number work, not less than drawing, painting, modeling, and written composition, depends upon the primary conception.

2. There must be a careful selection of appropriate units of measurement. The units chosen should be such as will involve the pupils least in the details of process, and which, at the same time, will best approximately define the image.

3. The most expeditious methods of measurement, or of applying the units, should be adopted. Estimate first; then measure. Neglect the fractions that are inessential to that general approximation which is within reach of the pupil's ability to image.

4. There must be a careful selection of processes by which the comparisons are made. This will be determined by the

pupil's ability to picture the different standards of comparison. The earliest processes will be simple addition and subtraction; then the use of fractions; later, ratio; then percentage.

5. The results obtained must be represented objectively. Gallons, quarts, pints, feet, yards, square feet, square yards, acres, miles, etc., must be seen until they become a part of the mental equipment, just as, for example, an idea of the color green is always at hand and ready for use. Proportions should be represented by diagrams and models.

6. Using the results obtained as data, a great nature picture must be constructed; that is, through the original and primary conception under which the pupil has been working, the real magnitude of world operations should be made to appear.

In the eighth grade, number work, planned in accordance with the foregoing, is being applied to several aspects of nature.

I. THE DISPERSAL OF SEEDS.

An attempt is made to form some idea of the rate at which plants might multiply, as indicated by the seed production.

1. Near the schoolhouse a vacant city block rather thickly covered with wild verbenas was selected for study.

2. By measurement and calculations this area was found to contain approximately one-fourth of an acre.

3. Areas of one square yard each were measured in various places, and the average number of plants was calculated.

4. An average of thirty plants per square yard gave approximately 36,000 to the quarter acre.

5. Each seed pod contained four seeds, one of which, on the average, it was found, failed to mature. The number of pods on a spike was counted, which, when multiplied by the number of spikes, gave 2,300 seeds as the average number produced by each plant. Since only three-fourths of the total number matured, each plant furnished, therefore, (approximately) 1,700 good seeds available for growth.

6. If these good seeds were properly distributed, and if each were to produce a plant, the one-fourth of an acre the second season could populate 425 acres—approximately two-thirds of a square mile, *i. e.*, equal to an area bounded by Cottage Grove avenue and State street on the east and west, and Sixty-third and Fifty-fifth streets on the north and south.

The third season, under the same suppositions, enough seeds would be furnished to populate 1,122 square miles, *i. e.*, more than six times the area of Chicago.

The fourth season, under the same suppositions, the area populated would be 1,907,400 square miles, *i. e.*, equal to about thirty-four times the area of Illinois.

The fifth year the number of seeds would be sufficient to furnish plants as thickly as those found on the quarter of an acre for an area equal to sixteen times that of the entire earth.

These measurements and calculations give (*a*) an idea of the vitality and the tremendous push and rush of the living thing; (*b*) since there is no such increase, as an actual fact, they indicate the degree of failure on the part of the plant to get its seeds properly scattered and safely planted, and also the enormous resistance offered by other plants and climatic agencies to the growth and spread of the verbena.

II. SEASONAL CONDITIONS: WERE THEY FAVORABLE OR UNFAVORABLE?

1. Rainfall: One inch of rainfall furnishes 540 barrels of water per acre, or 135 barrels for the quarter acre. During the months of May, June, July, August, and September, where the verbenas grew, the rainfall due the plants, according to the thirty-years' average given by the Weather Bureau, is 16.1 inches, or 2,229 barrels. The actual rainfall for three months in 1901 was 13.9 inches, or 1,874 barrels. There was, therefore, a shortage of 2.6 inches, or 355 barrels. That is, from this cause alone the vitality of the plants was reduced by about 16 per cent. This may be viewed in different ways: (*a*) that only about eight plants out of ten would grow this season; or (*b*) that eight seeds out of ten would mature; or (*c*) that the general vitality was lowered, which would be felt the following season.

2. Sunshine: The Weather Bureau records for the past eight years show that this region has received 65 per cent. of the sunshine possible during the months under consideration. In the year 1901 this area received 68 per cent. of the possible sunshine. It follows therefore that, since plants are most active in sunshine, there was an overstimulation of 3 per cent. above the normal. Since, also, during sunshine plants are most active in the transpiration of water, and since there was a shortage in the supply of 16 per cent., it follows that the combination of these two causes operated to intensify the strain upon the plant. The plant endeavors to resist this strain by reducing the leaf surface exposed to the sunshine.

3. Temperature: The average temperature for the five months for thirty-one years is 66 degrees. For the year 1901 the average temperature for the same month is 68 degrees. There was actually, however, an excess of 6 degrees during this time, as shown by the Weather Bureau records. This condition meant, also, not only a possible increase of plant activity; it meant more than the normal evaporation from the soil which would tend to cut off the water supply from the plant.

4. Variation in intensity of sunshine: On the 21st of each month the *distribution* of a given beam of sunshine at noon is proportional to the following

areas: May, 108; June, 105; July, 107; August, 115. These results are obtained approximately by the use of the skiameter. The *intensity* of the sunshine varies inversely with the areas of distribution. In the month of June, when the intensity of sunshine is greatest, the average cloudiness is 32 per cent.; in 1901 the average cloudiness was 31 per cent. Therefore, the withdrawal of the friendly cloud shelter by the amount of 1 per cent. in the month when the intensity was greatest served still further to increase the tress laid upon the plant in the year 1901.

These causes all happened to combine directly in this particular year to menace the future of the verbena. They also operated indirectly, so far as they favor other plants that know how to get along with the reduced amount of moisture and the increased amount of sunshine and heat.

The botany of the verbena, therefore, becomes chiefly a study of the various devices of leaf, stem, and root by which this plant is able to maintain itself against all these unfavorable influences, which the work in number shows to be actual and definite forces of enormous power.

GEOGRAPHY.

ZONIA BABER.

OUTLINE FOR ELEMENTARY SCHOOL.

(CONTINUED FROM NOVEMBER.)

WITH increase of knowledge, the necessity of a closer and more complete classification of facts is apparent. But, while the value of the cataloguing of information under the heads of history, literature, science, mathematics, art, etc., is admitted, its unwholesome reaction on pedagogy must also be confessed. The inseparable relation of the subjects, the interdependence of one upon the other, has been overlooked. The instructor has, for instance, tried to teach history from material within the covers of a book labeled by the historian, without recognizing the fact that appreciation of the behavior of men and nations in the past is absolutely dependent upon, and inseparable from, that knowledge which the geographer has classified under another head.

The understanding of geographic facts necessitates a knowledge of science, mathematics, and history, and demands expression in reading, writing, modeling, drawing, painting, and making.

In the course in geography outlined for the elementary